Mouth Bacteria

An Essay Presented to the Canadian
Oral Prophylactic Association
By W. J. Gies, M.D.
New York

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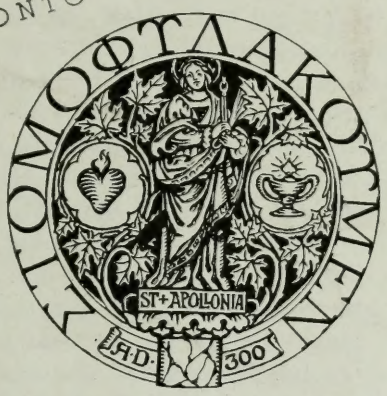

The
Canadian Oral Prophylactic
Association
Toronto, Canada
1918

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Mouth bacteria I mean to discuss in a very general way, especially from the standpoint of my own acquaintance with them, and especially from the standpoint of dental decay. Of all the disorders to which we are heir it seems that dental decay strikes us most frequently and universally. In the popular mind it is one of the most disturbing disorders, and, of course, in dental practice it is perhaps the most universally frequent. What causes decay of the teeth is a practical problem, and especially, if the answer to that can be found, how can we control the cause when we discover it? I believe you are familiar with the current conception regarding the factors that induce decay of the teeth. Let me repeat them simply to be sure we have a working basis to proceed upon. The current theory would, condensed, very briefly put it this way: The acid substance made on tooth surface repeatedly at a particular point causes solution of the enamel at that point, exposing the dentin, with solution of the dentin likewise, and exposure of the pulp likewise, if the process goes on long enough. The acid which is made at a given point repeatedly, which dissolves the enamel and penetrates, is made from carbohydrate by bacteria, the bacteria being invariably and always present everywhere in the mouth, the carbohydrate from which the destructive acid is made being localized at points where the solution occurs. I have condensed that, I believe, in the fewest possible terms. Acid as the destructive agent, bacteria the factors that make the acid, carbohydrate the substance that yields the acid, and what must always be kept in mind in running through this conception is localization and repeated production at the given point through a long period of time.

Now, if we know how to manage the bacteria, how to control the bacteria, how to identify them and destroy them, and so on; in other words, if we can focus our attention on the bacteria as the scrappers in a first line of trenches, if we can go over the top and clean up there, the rest of the advance is easy. What are the facts in this case? There is no cavity in the body exposed to the air repeatedly or intermittently that has so many bacteria in it constantly. There is no fluid that passes from the body ordinarily that contains so many bacteria

as the saliva, and it is a fact that practically any kind of organism that may be found anywhere may be found in the mouth. It is a further fact that while that is true, some bacteria cannot grow in the mouth, and some bacteria grow there preferentially. There are two reasons why some bacteria cannot grow in the mouth, as far as we know. One reason is that the saliva fails to contain nourishing material of a certain kind or necessary kind for them. They may go into the mouth, mix with the saliva, stick to the teeth, but will die because they are starving. Another kind, or group of kinds, will fail to grow because there is something in the saliva that is detrimental to them. Others will grow, as I say, because there is everything they need in the saliva, and the conditions are fine for their nourishment. So that we can think of oral bacteria as, first of all, almost unlimited in kind and character, so far as appearance and occurrence is concerned, but some will grow right along under all conditions, and there are others that will not. Those that die off in the mouth; those that starve there or are killed, are more or less immaterial from our standpoint. They may be very bad if swallowed, or if they pass through broken surfaces they may introduce disorders of other types than those we are concerned about, but only those types that grow in the mouth can have anything to do with causation of decay. We have studied in this period of research for the Dental Society in New York as thoroughly as possible two general questions: What are the general kinds of organisms roaming around frequently, dangerously and damagingly in the mouth, ignoring in our work those that were plainly of no importance by reason of death or general destruction, by impairment of vigor or what reason, according to what has happened to have been the case; and we have found at least three types of bacteria there that are conspicuous. First of all, the well-known types of streptococci. Streptococci viridin is one of the common types; and the streptococcus forms in general, including the type responsible for pneumonia, are very conspicuous in the mouth, in the ordinary deposits of all kinds, in the food debris mixtures, hard tartar, soft tartar, on the gums, on the teeth, between the teeth, on the tongue, and everywhere; and they grow all over the dental and oral surfaces by billions and trillions; they grow very luxuriantly, and no matter how often we disinfect the mouth, no matter how frequently we put disinfectants into the mouth, no matter how effective our mouth wash may be as a bacteriacide, the

fact of the matter is no sooner is it removed, and the saliva itself dilutes it and further removes it, than reinfection occurs, and it only takes a few minutes for generations to develop and restore the original population in number. Remember always that bacteria may pass from one generation to another in a few minutes, and it does not take a few days to develop a good sized bacterial family; grandfathers arrive and disappear in a period of 15 to 20 minutes in many cases, and so it is a very rapid growth. The streptococcus form is one very prominent. Then we find various types of bacteria of the so-called bacillus or rod-shaped type, and one of them is very common, significant from its name, bacillus acidophilus, an acid lover, a form that is very active in producing bacteria, and very resistent to the action of acid; and then there is another type of a globular form; and then there is the thread former, which is new, and which has not been described, which we call cladothrix placoides. Let me refer to these, now I have named them specifically, as spheres, rods and threads. The fact of the matter is those physical features are very important, and let us ignore the names as of Latin interest, but not of any practical value to us. The spheres, the rods and thread formers are very conspicuous.

Now, it is interesting to find when we study the properties of these organisms: first, that they grow readily in saliva; secondly, that they grow readily in tartar mixtures, and thirdly, that they grow readily in the presence of saliva and tartar and dissolve enamel, a sequence that you see is very important. They also grow very rapidly in these mixtures, and in growing excrete an acid substance; they throw out of their bodies, or at least they make, in utilizing their materials, large amounts of acid, and the one is called acidophilus, because of its very striking yield of acid. When these have a sufficient amount of carbohydrate to work upon they produce remarkably large quantities of acid, developing degrees of acid that are high in concentration; the acid mixtures they produce from ordinary grape sugar, malt sugar and cane sugar, and from starch, are acid substances of the kind that dissolve enamel very rapidly. So that it is plain that these are among even the very types that produce the acid from the carbohydrate which made repeatedly at a given point will dissolve the enamel, and in dissolving and pitting enamel they go right into their place and seem to be actually better nourished by going

there. These are among the striking facts pertaining to oral bacteria in general.

Our second problem was not only to make this general survey to become familiar with the forms, but also to try to determine the types of organisms at those points on the teeth where decay has just about begun, to endeavor to determine the types of organisms that may be found near the surface under which the very first indication of positive decay can be found, where the dentin has not yet been involved. I am sure you, as dentists, would say that is undertaking a pretty large order in diagnosis to take from teeth any material over a point that shows the earliest possible signs of initial superficial decay without involvement of the dentin. In the dental clinic at Columbia we would examine individuals, dentists co-operating with us did this—and they would locate points of suspected superficial enamel decay. We would take the material immediately overlying those spots and proceed with our usual bacterial examination; then the dentist would proceed to examine and determine whether his diagnosis had been correct. Was the enamel involved? If it was, it was a simple matter for us to record that the sample taken was not what we wanted. First we took what we thought was desired, and spent all the time necessary in the diagnosis. Working in that careful manner we obtained the material in mucin plaques from 40 different human cases, and we have studied the types of organisms to be found in that type of material. Our working hypothesis was that bacteria in this kind of material are and must be the forms which initiate the decay. We are more concerned in knowing what starts the trouble than merely knowing in a general way a lot of things that keep the trouble going. If we can prevent the beginning of decay it is obvious we prevent all the rest that may be involved. It was interesting to find these three forms I have mentioned, and they were outstanding in the general survey, were practically the only ones found in the study of the material in all these subjects of initial decay, and they are the types found in the mouth which individually and collectively produce from a given amount of carbohydrate the largest possible proportion of acid.

I call your attention to this, because each type fits into the requirements of our search for the organism which will make acid from carbohydrate, which will grow on a mixture containing dissolved enamel, and which will produce an acid that will dissolve the enamel. We found these types occur in prac-

tically absolutely every case, for some of the types, perhaps not the three collectively, were always present. It is very obvious, while we cannot say we have completed every possible variation on this enquiry, while it is possible naturally that others may be found not present that might be responsible, it does seem obvious after four years of continuous study of this one problem alone. We have concentrated likewise steadily for years in the study of, and in 40 odd cases we found the same thing—these types of bacteria as apparently the initiators of the decay. We have had some evidence that in some cases that one form is more responsible than the others. We are not sure that one form does not form the key through which the combination may work; we are not sure that one may not be the actual initiator, in time helped by the other two; we cannot say at present that the three do collectively work from the beginning; and that is the next phase of the problem to find out whether either of these three helps the other two to do anything; whether either one of them would accomplish decay by itself. We know they make acid individually that is destructive, they answer all the requirements, and they look to us as simply a combination which, working together, bores its way through the enamel with its instrument, the dissolving acid.

Now, I presume you have read often, and heard often, and have used often the expression "mucin plaque." I know that many dentists believe that decay is initiated in and under dental plaques when it is not initiated by some traumatic or some very special circumstance. I am not sure that dentists agree universally that that is true, but so far as my information extends a very great many dentists believe a mucin film, a mucin smear precedes, on a given surface, attack of the teeth.

One of the most interesting features of the thread form is the fact that it adheres tenaciously to smooth surfaces and forms a network of entangling threads. The spherical form does not happen to do that: the rod form does not do it, but the thread former, with its adhesive, smeary, sticky thread, will adhere to glass surfaces very readily, and we have found it on our test tubes, in which it is cultivated. So that even the most perfectly smooth surfaces will hold these threads and make an entanglement which I have assumed and suggested may be a mechanical sort of mucin plaque in many cases. These threads tending to stick, if they are not rubbed away,

form more and more of a network of underbrush growth, so to speak, in which this, that and the other thrown back and forth in the saliva will be entangled and make a pretty tough, tenacious, smeary mass, so that the anatomical quality of this one form is conducive to the deposit of the mucin plaque and the production of the so-called mucin plaque or film. It is quite possible further research will show that the thread former puts down the foundation for the entanglement. An entanglement again of an offensive kind—in this case not by any means defensive—is an entanglement of threads with their forms being held there conveniently against ordinary mechanical movement; then that the interspaces filling up and carbohydrate and food in degree being washed in would serve as a very effective medium for retention at these places and initial focal decay. Once the decay is started such an entangling is more or less immaterial, for the decay would go on without any particular mechanical assistance of that kind.

Now, naturally the question arises, if all this is true, if we know these to be facts, what may be done to control the forms of deposits of bateria in the mouth? What may be done to prevent the production of destructive acid? And we here confront what you know is at present one of the real practical problems in dentistry. Does anybody know enough to answer this question that I have just presented? Are we able to say how we shall keep bacteria from arriving at any point on the teeth? Are we able to say how bacteria shall be prevented from remaining where they go? Do we know anything that will enable us to prevent carbohydrate from going to those parts of the teeth where bacteria persist in going and remaining? Do we know of anything that will prevent bacteria from feeding on that carbohydrate and making acid? Do we know anything as to how to prevent action of that acid at this point when it is made by bacteria from carbohydrate thus delivered? And are not these fundamental questions? Your Research Committee, your Prophylactic Society, are unquestionably interested in the answers to all these questions. What is mucin, and what is our present scientific understanding of the quality and nature of this material? I believe this must be clearly understood by any investigator, and by any Research Committee, and by every dentist who wishes to proceed with understanding also of the practical facts in the case. Mucin is one of the albuminous substances, also called protein, which happens to be peculiar or different from nearly all the others.

It is albuminous matter, combined with carbohydrate or sugary matter, and the technical term for it, descriptively, is glyco-protein—mucin is also called a gluco-protein. It is very much the same as saying it has the principle of the artificial combination of egg white and sugar. While that would be a combination that would not look like mucin, it would be in principle like it. If we were to take the typical albumen in egg white and combine it with sugar we would get a combination that in principle would be like protein. Mucin is protein of this peculiar kind. It occurs in various parts of the body, as well as in the saliva. It does not occur in the blood; it occurs in bone and ligament and in tendon, and it occurs especially in all embryonic tissues. It occurs in all the ordinary secretions. It is protein of a very peculiar kind. Secondly, a quality that is striking is that it is an acid substance. It is a protein acid. It is about as weak an acid as boric acid; in fact, it should be said it is weaker. It is an acid substance that has the power of making a number of affinities per unit of its mass per molecule. Boric acid has three replaceable units in combination with basic matter. Mucin has more than three, but it is so feeble in its tendency to react with basic matter that we say by reason of this general disinclination it is a very weak acid. That is a striking chemical fact about it that must be kept sharply in mind. When you obtain mucin from saliva itself, or from any place else where it appears, and you proceed to smear that on enamel it does this interesting thing: it will dissolve the calcium out of the enamel. If I take saliva, or if you do, and add an acid to the saliva that is stronger than the mucin, say acetic, the acetic takes the base away from the mucin, because it has an affinity and it leaves the mucin without a base; then the mucin separates and curds. We can take that out and purify it and wash away the debris and get pure mucin. If we take pure mucin and put it on enamel or mix it with pulverized enamel, we dissolve the calcium out of it. The mucin changes the part so taken from its curdy, insoluble form to a soluble form. In other words, we have taken from the enamel a base to make a salt of the mucin, and that salt being neutralized, now goes into solution. It combines with saliva. Saliva ordinarily contains no mucin. Mucin combined with a base in the form of a salt which is hydrochloric acid does not appear in the blood, but sodium chloride does appear in the blood, and potassium chlorate appears there.

I may be seeming to be using a lot of words without saying anything important. Let me warn you what I am saying is something that goes right to the heart of certain points on erosion, and is not something without meaning.

Mucin is protein acid which has the power of combining with bases to form salts that are soluble and disappear readily in water. Mucin itself is insoluble in water; is insoluble in saliva. When mucin gets into the normal saliva from the salivary glands it is in solution; it is there as a salt. It may be only one part of its capacity is saturated; it may be only two; it may be only three; it may be all are saturated. The larger amount of base combined with it the more perfectly it goes into solution. Mucin salts have a remarkable affinity for water, combine with water, so that if I were to take 2-10ths of a gramme of sodium of mucin which I had made from saliva and would put it into one hundred centimeters of water it would readily dissolve or go into solution, and I would get a mixture like thick mucous. The water has combined with the salt to make it a viscid mixture, the product dissolving in water at the same time. In other words, I could present to you sodium mucin 2-10ths of a gramme and one hundred centimetres of water, and put it in it, and present to you what you would agree is good, ordinary, very thick saliva; and for our demonstrations, when we lack saliva and must have it in a few minutes, we present it in that form with entire propriety, and even some of the assistants can't tell the difference. The viscidity is there, and we now know it is mucin salt that imparts the viscidity to the saliva. We know according to the stimulation applied to the salivary glands the mucous matter will come out thick, having much mucin in it; or come out thin, having little in it; that the thickness or thinness of the saliva is dependent on the proportion of sodium mucin in it. Each of the three types I spoke of lives in the presence of all of the types of mucin that appear in the saliva; it thrives on it. It splits the carbohydrate off from the mucin, and it can make acid from mucin carbohydrate. I will repeat that. The three types of organisms can and do grow in the presence of sodium mucinate. They tend to feed on it, and fracture it into its parts. Some of the parts they thus get is glucose, and they can make acid from that, as they can make it from any glucose given in the first place. Secondly, when a sodium mucinate smear is made on the teeth or anywhere, and the bacteria that I refer to grow in it and make acid there or something else,

the acid eats into this mucin film to a certain extent and precipitates the mucin, curdling right around the bacteria, helping to pack them down all the tighter on the surface. If there is a smeary, adhesive film all over the top it packs it down very solidly, and is very good food material, and is also very good productive material. These solid flakes have no action on the bacteria whatever, except simply so much piled up food when food is called for.

Another interesting thing about the mucin film is that despite its smeariness, despite its adhesiveness, sugar in solution will diffuse right through it. In other words, if I take a suitable medium, let us say a piece of animal membrane through which a solution of sugar will pass readily by diffusion; if I take a pig's bladder and put water and sugar in it, and then immerse the bladder in water for a little while, I can soon show the sugar has passed through it. If I put a mucin smear all over the bladder and let it dry to any degree of dessication, whatever the degree may be, and I put it back in the water, I can get just as rapid diffusion through that mucin film as if it had not been done. Or if we put a mucin film around the bag and then immerse the bag in mucin smear itself, the sugar will go through the bag, through the mucin to the very limit of the mucin mixture.

Now we know that diffusion, in other words, of carbohydrate, the acid yielding substance, will occur in all directions through mucin smears. Observe what happens to our conceptions of causes and effects. If a mucin smear forms anywhere on the teeth; if it forms upon a place where there are no mechanical movements to remove it, and sugar of any kind is taken into the mouth and dissolved in the saliva and distributed, the minute sugar comes in contact with the surface the sugar will tend to go right inside. If bacteria are there, covered by this abundance of food, and it has an opportunity to stay there, they will feed on the sugar that goes in solution through the film to the teeth. We do not need to think of sugar particles or starch particles, or food mass with the carbohydrate in it visible to the eye. A carbohydrate that is in solution, that diffuses into the mucin, is just as responsible for decay at that point as any other.

Now, what are the things that will distribute the mucin smear effectively? In the first place, the mucin film to some degree tends to form all over the teeth. We know that. In fact that seems to be desirable. I might state another

physiological fact, well known about mucin: if you take two equal quantities of water and expose them in flat evaporation dishes—for instance, two saucers—and put a small amount of mucin in one and stir it in, and none in the other, the water in the mixture that has no mucin will evaporate readily. It may take one day to evaporate; it may take three to four days for the water to get out of the mixture with the mucin in it. In other words, mucin retards the evaporation of water from the oral membranes and from the teeth, and it unquestionably functions everywhere in the mouth as an efficient agent in keeping a small amount of fluid evenly distributed, helps to keep that fluid in the position where it will keep all parts moist. Of course, you know teeth must be kept moist in order to retain their normal state, and when you stop to think of the amount of hot air moving back and forth ordinarily it is an important function which it does perform. Mouth-breathing in some individuals is unquestionably bad for the teeth by reason first of all of the alternate expansion and contraction of the enamel that ensues.

Doubtless you have all realized when a tooth lies exposed to the air, removed from the mouth, and tends to take on its more and more decayed character, what is happening is simply loss of water. You can restore the original weight of the tooth by putting it into water and giving the water a chance to go back. Researches have recently shown very conclusively that substances may pass back and forth from the saliva into the teeth in all directions, and that water and common salt and sugar are amongst the substances that will go right through slowly, but surely, just the same. So the mucin film will hold the carbohydrate, will permit it to enter, and will be a kind of trap for this stuff that yields that acid that causes corrosion, that opens the enamel, that drills the dentin, that builds the house that Jack built, and so on.

How shall we manage to get rid of these films which overlay the teeth universally? When I bite into a sour apple I feel that my teeth have been put on edge. I am sure they have not been sharpened, but something has been taken away from them that previously lubricated them. When we get that effect, what actually happens is we remove the physiological film from the teeth, and for the moment the teeth lack the gliding, easy, non-frictional surface movement. It is evident that that kind of material would remove the mucin plaques. We know chemically that such material does. We also know

that alkaline mixtures dissolve mucin. Among the alkaline substances that are commonly employed to accomplish this result, either knowingly or without comprehension of the matter, have been such substances as sodium carbonate, lime water, soap, and even the miserable alkalis, precipitated chalk and phosphate. We know that alkali by coming in contact with mucin saturates the compound, the basic matter, and makes it more and more solvent. It tends also to make it more viscid; it tends to make it softer. The bristles are not effective in brushing such a surface; the bristles may go through the smear as they might through molasses. They would furrow it, but the material would move up and close up by its viscosity, so that if the alkali is of the kind that makes the mucin soft, and mechanical effort is not effective, the mucin is not entirely removed. One of the improvements in the treatment of linen that has been soiled by mucous collections of all kinds, such as from the nose on an ordinary handkerchief, is to treat the linen first of all with some kind of acid which curdles the mucous matter—it pulls the base off and breaks its grip. Curdled mucin has no particular grip. Even cloth can be flushed up and down in water, and it all comes away, but when you try to wash such a collection with alkali you find you have got to use acid friction to wash it out after you have got it soft. You make it more adhesive, and you increase to some extent the mechanical difficulty of its removal; and in order to accomplish the mechanical removal the use of abrasives has long been employed. It is well known why one uses an abrasive; if possible an abrasive that will do no harm to the teeth. Such material as precipitated chalk and phosphate gives the bristles in the brush a certain amount of breadth and punch and push that by themselves they would not possess. An abrasive mixed with an alkaline mixture can be regarded as something highly efficient in the removal of the mucin plaque.

I am sure it is nothing new to suggest that there are at least three phases of the problem of keeping bacteria moving on the teeth. If we keep them moving and keep them from colonizing we may say we prevent any hurtful result. Those three phases seem to me to be: first, the use of a dentrifice or its equivalent that will not injure any part of the mouth or person; secondly, the application of the dentrifice by an instrument that will put the dentrifice where it ought to go; and third, the development of a disposition and purpose on the part of the individual person to use that dentrifice and put

it where it ought to go with that instrument. And if you cannot get a combination of those three things in your subject the whole system breaks down. What is the use of the dentrifice if the person won't use it? What is the use of the dentrifice if it is not even put where the dentrifice will remove something? What use may it be, for instance, on the upper incisors, which may be kept in certain individuals entirely clean day in and day out by means of the lips alone? It may be useful there in some view, but theoretically is that the only part of the mouth to receive any special attention? And yet how many of our people believe what they can see is the main part and only part to deserve any special attention. What are we doing as scientific men, as dentists, as citizens, to improve the situation in that respect? I am very glad to find your Research Committee and your Prophylactic Society have taken up this very series of questions. Of course, they will consider these problems, since they are the three first ones that logically must come to every mind that reflects on the subject. What is the best dentrifice? May be there are lots of them; may be half a dozen are *the* best in the sense that if properly applied each will do what it ought to do. What brush, what method, what instrument, will carry the dentrifice or dentrifices to the places foreign matter and bacteria should be taken away from? What are we going to do to have each individual person realize from childhood that proper, earnest, effective care of the teeth is an important feature in the maintenance of the health of the individual? Associations such as you have, unquestionably, by taking the attitude they are today, ought to serve the people at large in the provinces; and I say associations such as this suggest the key and provide the answer to the broad question. This will never be accomplished by the individual dentist, that is plain. It will not be accomplished by the individual dentist unless he works with a feeling that he has a composite of experience and belief and conviction and fact to warrant his recommendation. We all know that the manufacturer of products, the manufacturer of goods of any kind will sell those goods; let us say legitimately, without any comprehension professionally of their shortcomings in many cases. It is not necessary to say that the business man who wants to sell a dentrifice is necessarily wrong, or even crooked. We know many of them are; but it is also true much of it is in plain ignorance

This leads me to comment, in passing, on another matter, and I am sure now you will see the resemblance between Artemus Ward's speech and my own. I am led to refer to acid for the benefit of those who may later, or even at the present, have occasion to think this matter over. It is interesting to find how the word "acid" tends to impress the average person as meaning the limit of destructive matter. The acid test, for example the boric acid test, wouldn't be much to apply to a recruit—sulphuric acid would. He could take some of that in his hand and hold it for a while and he wouldn't be fit to go across. If he could take boric acid he certainly could get away with the test. There is so much difference between acids that they range all the way from the kind that has practically no acid action at all to the kind that has practically no other kind of action. Take boric acid. You can make a saturated solution of it, and you can drop all of it you want on the eyeball, and you can do that with therapeutic purpose and therapeutic effect; yet you have taken the strongest possible solution of boric acid and benefited one of the most sensitive surfaces in the body—the eye. You would put boric acid into the mouth freely, but you would not put sulphuric acid. What is the chemical explanation of this great variation in acid? You would not hesitate ordinarily to take a spoonful of grape fruit juice, that has acid in it in great abundance, very strong acid. You may put sugar on it even to disguise the taste of the acid without neutralizing the acid or reducing the quality of it. You may like lemon juice, that is much more acid than grape fruit. You may like something pickled with vinegar, which has as much as seven per cent. of acetic acid in it. Acids are alike universal in one important respect—they are compounds of hydrogen. It does not fully define it, because something else must be said beside; but all acids are compounds from hydrogen. Hydrogen to which I refer is always, in part at least, of one kind. Let me say it this way: Some of the hydrogen in every acid is replaceable by some other like base of the sodium potassium type, but some of the acids when dissolved in water yield up the hydrogen in this respect so slightly, so poorly and so little in degree, that there is very little reaction with them by other things. They tend, in other words, to react slowly and almost not at all. At the other extreme, such as sulphuric acid, the hydrogen is so free to jump to something else and get out so that a base can come in that we speak of

it as a strong acid. The fact of the matter is, the stronger an acid happens to be the more its hydrogen is willing to jump through water to another position and give way to a base. In other words, it is disassociated away from the rest in the water more readily; the water, when it goes into solution, separates it from the rest. A strong acid is an acid which yields up the largest proportion of hydrogen when it goes into water solution. We say acid is disassociated and the hydrogen ionizes. Faraday manufactured the word one hundred years ago. The acid disassociates the water and hydrogen ions, when abundantly produced and makes a substance which is a strong acid. When, on the other hand, hydrogen tends to stay with the whole mass when put in water and does not tend to go out, we call it a weak acid. In boric nearly all of the hydrogen stays with the rest; it does not disassociate; it does not go away; it does not ionize; it does not tend to run off on its own hook; whereas sulphuric put into water tends in the other direction, and hydrochloric, nitric, phosphoric and quite a number of other acids do the same. Acetic and acids of the fruit acid type, such as are present in fruits, are much less inclined to do it than sulphuric, and yet they are also inclined to this to some degree. So that we may say we have a strong solution of a weak acid, and mean by that a high degree of concentration of a weak acid. We may also have a low concentration of a strong acid. It is about the same as saying we may have a large number of weak men, or we may have a small number of strong men. We think there is no contradiction in the terms at all. So we may have a large proportion of weak acid and we may have a small proportion of strong acid, and then we are very apt to say we have a weak solution of acid or a strong solution of acid, and get all twisted up in our terminology. The acid that we take into the mouth in salads and foods in general has the interesting effect on mucin of tending to break up the salt by pulling the base out of it, curdling it, loosening it; and then we say our teeth are on edge. Pickerol, of New Zealand, who has published a very valuable book on this and relating subjects, has called attention to what others also independently have concluded, for much the same reason, that it is a wise thing to terminate a meal with a normal natural acid food. For this reason a number have agreed on this wholly independent of each other. It is a very interesting point that a number of men, widely separated upon the earth, without wireless communication, have arrived at the same conclusion;

and the point that is made is this: that food acid, like grape fruit juice, apple, orange, lemon, salads and so on, ordinarily have a relatively high degree of weak acid, enough to curdle all the mucin and break up all the plaques present on the teeth at the time. If we terminate the meal that way we are not apt to leave any solid starchy, pappy, pasty mass in the mouth; or if we take the precaution further to select these natural things that happen not to have them, or if they do have them, they appear in large pieces in the mouth that are more or less easily moved along. In other words, instead of terminating a meal with a soft, pappy, messy, adhesive, slimy stuff called dessert, we might end up with something as common, even in war times, as an apple. Take an apple, for instance, and put a little cream on it and you have all the pleasant associations of a dessert without any disability. The fibre, all of it together, works effectively to help to clean the mouth. In fact the more you must chew the dessert, and the more nearly it agrees with the acid normal food conditions, the more thoroughly you cleanse the teeth without thinking about it. If we were to terminate each meal in such a way, instead of perhaps starting a breakast that way and ending with something sugary—if we were to terminate the meal that way we would accomplish a great deal without even seeming to be doing it, and aiming to do it. Then we have another very interesting virtue in this relation. Of all the things which, put in the mouth, effect the most striking taste stimulus, the most striking chemical stimulus to the salivary flow, the food acids happen to be those things. Food acids will make the saliva flow with extreme abundance. There is normal physiological afterflow, so that if you terminate the meal with this kind of fibrous acid material you cleanse the teeth mechanically, and facilitate the afterflow of the saliva, which presumably has the virtue of alkali, more or less desirable to replace the film which is physiologically desired. These are factors, then, that cannot be presented as solving all of the problem, but they are easily-adopted procedures to help. They are recommendations that have also the element of sanity and the element of ordinary common-sense, and they fit in to what might be said to be good dietary habits. If you can, get each of your patients to eat three apples a day. I assume they are of ordinary size to suit the body of the individual. Have you ever heard of anybody suffering any material injury from a habit of that kind? What about a family that gets this good.

solid, substantial kind of material? I understand apples are very abundant in New York State; but I am not here representing the apple growers' association. Perhaps you have them more abundantly in Toronto. Lemons from Florida will do just as well, or oranges from California; other fruits, whatever they happen to be, outstanding likewise. It points to this fact, that all fruits, with very few exceptions, are acid enough to break the mucin film. I remember looking into this a few years ago and finding to my astonishment that while watermelon and canteloupe and certain forms of very sweet cherries did not, that all the other fruits, in a selection of about thirty, did have the power of precipitating mucin from the solution. Squeezing the juice out and mixing with mucin solutions gave a prompt precipitate, and I remember of all the various types of apples we took, one part of the juice in sixteen of water would precipitate mucin from the mucin solution. It requires relatively little to do it. Therefore, when you bite through an apple, or through an orange, or through any food acid mixture, you accomplish, if nothing more, at least the prevention of an after deposit or composite of carbohydrate matter that is very desirable, and stimulate an afterflow of saliva; and if now in between we use suitable dentrifices and brush properly, then with ordinary superficial cleanliness we will prevent the disease we are talking about, and we will assume we would accomplish it.

This leads me to raise another question. Under the auspices of the National and New York Societies we have been studying for several years two questions, one of which we believe we have settled. One is the relation of supho-cyanide to dental decay. I imagine that as the centre of interest in that particular problem is in Buffalo you in Toronto in the past have heard a great deal about it. I don't believe you hear much about it any longer. The reason is when the problem was studied, without any enthusiasm for or against anything, without any of that bias that is developed through the empirical belief, standing by one's guns, that it is not a good thing. On the other side, standing by one's guns on a wrong opinion is heroic, but the guns are sooner or later captured. Sulpho-cyanide is one of the very obvious ordinary waste products made in the liver and eliminated by various channels, including the mouth, and it never had any relation —and never could have that anybody could make out—to any purely physiological disease like uricemia in the urine. That

also appears in the saliva, but if I may reasonably suggest, it has no relation to the disorder.

The second problem is: the research men in the society concluded, after two or three years of observation, that these facts had been made out so definitely and conclusively that it was possible to turn in another direction. I said a little while ago, as I touched on the question of cleaning the teeth, that if we keep them by these various means entirely clean, if complete and effective superficial cleanliness will prevent decay, then we will have succeeded. We have been studying two other problems, and the second one bears on that assertion. We are trying to find out under the auspices of these two research organizations whether teeth vary in any material way from the inside, or underside of the enamel. Has anybody shown that they do not? Does dental literature show conclusively that they do not? I am not saying anything; I am asking questions. Does dental literature show that teeth will not in places, in spots, undergo disorganization from the underside? Does dental literature show that all enamel on all teeth is perfectly formed at the time of formation originally? Does dental literature show that during adolescence decay is more frequent than at other times? And if so, has it shown why? Does it follow it is due to systemic alteration in the person; or may it be just at that period when initial defects in the enamel to start with are in a sense in that way showing their presence? Can anybody answer these questions? I am assuming these remarks may be discussed, and I am putting tantalizing questions, because I am here not only to discuss, but to learn. Has any dentist shown when decay suddenly seems to strike a person, to the amazement of everybody involved, that it is due to a cause then active, excluding a prior cause; or has anybody shown it may be due to defects that are now showing simultaneously? If men may develop in families, generation after generation, rheumatism at forty or diabetes at thirty-five, or cataract at fifty, may there not be defects in the enamel, while not so effectively timed, which may have run along and show themselves at such periods as to lead the dentist to think that during the last few months something has been going on? Does it follow that what we find in the chair is necessarily due to causes that began to act since the last visit? These are questions difficult to answer, and while we may believe a lot I am sure we know relatively little about them. Now we have raised this question, does

enamel undergo any abnormality during its development that we can induce artificially? If it does undergo abnormality when produced through artificial intervention, is it a uniform abnormality? Can we make it abnormal in spots and can we make it abnormal universally? We have assumed as a working hypothesis that in all research work, first we must have a conviction that we are ready to abandon when facts require; a surgical operation ought not to be necessary at such a time. A man who starts with a working hypothesis and feels it is humiliating to give it up is the type of man that is bedevilling dental science and has no place in the career of the investigator. He ought to have pride in achievement in revealing the truth. He ought to have the same pleasure in saying, I was wrong and you are right as in saying that the other fellow was wrong and he was right. It is the other spirit that is leading us to have so many partisans on the root canal proposition —not enough open-mindedness and too much emotion.

We have endeavored to find out, if we can, just what the facts are, and our working hypothesis was that the glands in the body that are notably inefficient in co-ordinating must have something to do with the production of the teeth. You are aware of the fact that when the sexual glands are removed the individual that develops afterwards is a far different individual than when they are there. We know the sexual glands produce substances that are absorbed into the blood continuously and that the function of these substances is a physiologically continuous function, especially shown actively during the period of puberty, during the period when the secondary sexual qualifications of the male and female rapidly develop and become striking. Just as those are popularly understood phenomena and facts, so we find in the study of physiology that one part of the body will do this or another if increased or decreased. We know a certain abnormality in the brain will lead to a remarkable extension of the body; the feet will become excessively large, the jaw bone may do so, the hands may do so, and it has a tendency to acceleration of extension. We notice that that part of the body must have a profound influence on the growth and mineralization and calcification. We know that when thyroid is interfered with by disease then an individual may be dwarfed. Again we know there is marked disturbance of calcification and ossification. We know when the thymus, which is above the heart in infants, is normal, there is a healthy growth, and when that thymus is

removed in part or in whole, or when it is diseased, that growth is interfered with. Let me give you two illustrations of the driving effect of the thymus and thyroid. Tadpoles we are all familiar with as organisms that rapidly grow from one stage to another, from the tadpole stage to the frog stage. A little tadpole can be watched day after day going from the tadpole to the frog stage; you see little limbs come out on the side and so on, and it is all a matter of easy observation. Take a certain number of tadpoles from a given supply, feed one-third of them with thymus from oxen or any other animal, feed another third with thyroid, and feed another third with meat, and note what happens. Those that are fed with meat go on as pollywogs through ordinary development to frogs; those that get thyroid go to the miniature frog condition, they become precocious frogs, whereas those that have been given thymus become giant tadpoles, they do not take the form of the frog. When thymus and thyroid work together in you and me, they have given us this miserable composite, whatever it may happen to be. We may be so long, so wide, so thick, whatever the phenomena are, and are very apt to be regulated by these two effects. Parturea(?) has something to do with it. Parathyroid is the very minute gland situated beside the thyroid. The parathyroid gland in the throat of the human individual is hardly larger than a small grain of corn. If we take the parathyroids out, convulsions severely ensue, and there is a marked disturbance of the calcium. If they are taken out of the race. the young race, nine out of ten, will fail to live, they die in convulsions, but now and then if we use a sufficiently large number, one will overcome the convulsions and have resistance enough to live through it. When that animal does survive, the teeth are very poorly calcified. The abnormality due to the subtraction of this gland causing disturbance in the calcification. With these facts before us, what ought the earnest investigator to conclude? If all these glands and all these disturbances will affect ossification, extension, placement, why should not one of them or a combination of them have much to do with the teeth? We have gone ahead studying this proposition from the standpoint that we have mentioned, and thus far we have found that some calcinous additions cause better calcification, some have no effect, and some impair. We have found that some subtractions do the same—additions and subtractions have effect. I am not going into the details of this, for it is too long a story; what I wanted to

go through this far was to speak of or to lead up to this thought, that among the things we did to answer the broad question was to find out whether anything could go from the blood into the developing enamel, for if nothing could go from the blood into the developing enamel, there wouldn't be any use studying this at all. We did suppose that they might affect the salt that would make the enamel and would hold them in reserve, and we started always with a working hypothesis, right or wrong, we don't care, something to go on; if it is right, well and good, if it is not, it doesn't matter. The working hypothesis is that something will go through the enamel, will go into the enamel if it is in the blood, and is there while the teeth are forming. Now, many coloring matters may be introduced into the body which will be widely disposed all through the body and show themselves. Some coloring matters when introduced into the body will disappear. In the treatment of the sleeping sickness, one of the coloring matters that was recommended for the destruction of the organism that is responsible for it, was what is called now tripan blue. There is also a tripan red and quite a number of others that are among the so-called pansoden dyes. When these coloring matters enter the body they kill some germs. They do not enter the nervous system to any degree, which is a safe feature, but they distribute all through the blood, all through the body. An animal receiving an injection becomes tri-blue. If we take an albino rabbit and inject tripan blue into the abdomen, in a few minutes you can see the animal is certainly looking bluer than it feels; it plays around the place entirely happy and steadily gets bluer, bluer and bluer; the whites of the eye take on a blue, the red gets purple, and if you make a few such injections at intervals of a few days, you can get a rabbit that looks as if it had been painted blue. The only thing about it that doesn't get blue is the hair and nails, there being no circulation into the tip of the nail and hair, and no color has a chance to go up; but if one performs an autopsy, it is amazing to see how blue it is. I don't recall any blue color I have ever seen that is as intense as some of these blues we have induced in rabbits in this way. White rats, dogs and human beings all take on this striking blue color. That color slowly fades. We injected the tripan blue into rabbits, rats, guinea pigs and dogs at various stages in the development of the enamel, so that we would inject some of the animals when the whole of the teeth had erupted, some of the animals when

the second teeth had undoubtedly formed in large degree but had not erupted, some of the animals when the first teeth had not appeared, as in the case of very young rats; they were there but had not erupted; and so we made injections in all gradations, and we found this, that whenever the tripan blue circulated in an animal, it went into all of the enamel that was being formed. I have two dogs(?) in our laboratory yet, having shown two of them at the meeting of the National Dental Association in October, which had received injections of tripan blue when they were very small, the last one received on the 23rd of last July; the teeth had not yet erupted; and those teeth are blue from the top of the crown to the apex of the root. They are blue in all parts, although now we know from extractions that the pulp has lost its blueness, but the enamel is still blue and has not faded, or if at all, the fading is so little as to be practically negligible. There is a foreign substance of the kind that is not diffusible. It is a so-called collodiol substance; that substance freely moved around in the enamel cells; it was undoubtedly thrown into the enamel much the same as dirt or any extraneous matter would be thrown into a wall when brickmakers are putting up a wall. It shows conclusively that abnormalities in a person that may be registered through the blood or in any general way in the enamel cells will lead to imperfections, placements, displacements and modifications of the enamel. Here is an ocular clinical demonstration of the fact that enamel is subject to influences that may be shown to the eye while the enamel is being formed. Now we naturally thought of a question that sooner or later should be asked: did any of that tripan blue go into any part of the tooth that had been formed? And the answer to that question is no, it didn't. The enamel that was under the gum line that had been formed, though the coloring matter was freely circulated, didn't enter the enamel, and none of the enamel that was outside and beyond the gum line was at any time affected by this treatment. While the coloring matter goes up into the pulp and permeates it perfectly and makes it a deep blue, most painfully blue, and you imagine it must have hurt terribly—while it will go to the full extent of the pulp and will go into the dentin, it won't go into the enamel. We have tried other things, such as arsenic, and the result of it all is we have undoubtedly found that substance will go into the enamel while it is being made and will make that more or less perfect, rarely more; and I believe that it must be con-

ceded that some features of decay may be (I emphasize "may be") typical of that kind of deficiency in the enamel which will show itself after some years of ordinary contact of hostile conditions in the mouth. Certain spots may be more or less susceptible by reason of deficient formation.

Another matter of interest comes to mind, and that is the chemistry of the enamel. Enamel is nominally a homogeneous film that may be regarded as entirely uniform throughout its mass, and made in a way that would render inperfection difficult. It is just the opposite. It is made of a very compact, dense, prismatic structure, these prisms being held together by material of similar composition though not in form. In effect, it is much like saying the enamel is made of cells of hexagonal prisms in a certain direction and then track these prisms very slightly with a similar substance chemically. Think of the possibilities of variation in that structure alone. Enamel does not shoot out into crystalline forms right away, one after another. It is like building a tall chimney, and the slightest deviation in the courses involved would mechanically change it and change its angle of approach, would tend to make it convergent or divergent according to circumstances, and would tend to make the deposit resistant or not, and might mean that the outer surface of the enamel through a certain distance here, there and elsewhere, would be resistant and would not be any other place. It seems to me it is a perfectly sound hypothesis that enamel is just like every other part of the body, and when it is being made it is subject to variations in quality that will not show by ordinary inspection. Now, the composition of enamel is, so far as its pure chemistry is concerned, ordinary calcium phosphate is molecular combination which gives this product an unusual resistance to attack and dissolution. We know calcium phosphate dissolves very readily in acid, but we know that the combination in the mouth does not dissolve readily in acid. It will dissolve with repeated focal attack and repeated molecular production, like water dropping on granite, there may be a wear and tear there. But in the case of enamel we know that calcium phosphate is combined molecularly with calcium muriate or calcium chloride, or both, and we get the equivalent of calcium phosphate in the mineralogical apatite, present all over the earth in enormous masses, and interestingly enough whenever we find it it will be found to have hexagonal crystals. It stands weathering influences. That product as we find it in nature is calcium

phosphate, calcified fluorid or sometimes a calcium phosphate and calcium fluorid combination, an alliance between the two that makes this a very resistant combination. In enamel we find that there is more carbonate than ever appears in apatite, and the results we are now getting in the laboratory show the carbonate part that becomes part of fluorin and chlorin is variable to a surprising degree in teeth.

Now I feel that we are going to find in this relation, as we have in some others, as we did years ago in the iodine proposition—we now know that iodine in small quantities is absolutely essential to the life of each of us, that our thyroid gland cannot perform its labor unless it receives from time to time small amounts of iodine; we get that in water and in food and in various ordinary ways; when we do not we develop goitre. One reason why the painting of goitre with iodine has so long been effective is because that iodine goes in and replaces the iodine that is missing, and in Switzerland, where water is the chief source, and in some portions snow water without iodine, goitre is endemic.

Fluorin is talked about more or less frequently as a normal physiological constituent, but nobody has laid any stress on its function. It has always been found in teeth. Now, we never pay any attention to fluorin as a constituent of the diet. We usually, in such things, pay no attention until we must. We simply let it go until it is unavoidable. So it is in this case. We have learned also another interesting thing, that the thymus gland which is so interestingly connected with extension, has more fluorin in it physiologically than any other part of the body. Note the possibilities. I made a suggestion two years ago from that finding, and we are getting data that seems to show conclusively that thymus mobilizes fluorin, a sort of central station from which it is distributed in the quantity and in the condition in which it ought to arrive where it will be used. Just as thyroid mobilizes iodine, it looks as if thymus does that with fluorin, and now it may happen that diet deficient in fluorin might account for the poor enamel formation when enamel is being produced. It would not account for poor enamel structure after the enamel has been made.

Now, gentlemen, I have exhausted your patience, and I have gone away beyond what I am sure is reasonable, but as I am a convert to dental research from another field, I have not lost my love for my first love either. In going into this new field I had gotten into it long before I fully realized its

vast, wide-open possibilities for the most active, earnest and effective usefulness, and the whole field in its opportunities and possibilities has appealed to me so much that my enthusiastic interest in the matter usually gets the better of my judgment. I am very apt, when I get the opportunity, to speak in this rambling way all over the lot, anxious to bring out suggestive things, to cut out the technical detail and to try to make it something that can be remembered in its main points, which it is the function of the lecturer to present. I might have given you photographs of bacteria, showing them with their many Latin names, but I have tried to show you I don't know anything about dentistry, but I am trying hard to learn as much as possible. (Applause.)

I don't take this applause to mean an encore, but it reminds me of something which I agreed to say, and that is something that bears on the observation with regard to root canal filling, so please understand this and know that I am starting all over again. As to root canal filling, I don't know anything about what may be said to be the best method of doing it. I don't know whether it is desirable to permit a tooth that has lost its pulp to stay in the mouth or most desirable to remove it, but I have seen this one thing in New York, naming no dentist, and assuring you it makes no difference to me what the facts are, but anxious to know what they are. Let me visualize in the terms of one who was present that every particular remark I make is absolutely accurate in detail. I have seen an ex-Ray photograph from a given particular case in the hands of the dentist whom many of you know and who, I would say, is absolutely reliable and could have no occasion to fool himself or anybody. The pictures, one after another in series, running through a period of about six to nine months, the first showing the condition of the ordinary blind abscess, very profuse, very wide extension. I should say a big bulging abscess at the root of the tooth. The picture I saw next presented the tooth with the gutta percha filling, after all ionization and sodium of potassium treatment, pushed in as far as it would go beyond the opening, then packed tight with chlora percha, and I believe put in in every way to get it in solidly, to make it tight, filled with gutta percha, and apparently all ready for inspection as to whether it was there or not. The picture showing the gutta percha tip away down it seemed to me, and to us and those who looked at it, to be at the very bottom almost of the abscessed cavity from which the material had been taken, or at

least had been made soft enough or was soft enough from whatever happened to permit the point to go down to the lower rim of this rarification. The point happened to be sharp, there was no bulging around the opening of any kind, but it happened to go right through beautifully, in fact it couldn't have been drawn to order any better than it seemed to be. The next picture, about two months afterwards, showed that while everything at the top was the same, the gutta percha tip wad turned, the lower border of the rarification was higher, suggesting regeneration and pushing up. Later the picture in the series showed the regeneration had plainly gone much higher and the gutta percha tip was again slanted over; and the last picture I saw showed very plainly that the gutta percha had been turned almost at right angles, the gutta percha tip had been completely surrounded by what seemed to be regeneration tissue. When I told this in private conversation during dinner, it was suggested that this direct observation of the fact, whatever it would mean, might be of interest to you. I don't pretend to interpret it, except the picture looked to me as though there had been regeneration and turning up of the gutta percha point as the regeneration advanced. Whether that tooth was any better in that person's mouth or not, you naturally would determine; I can't.

After considerable discussion and Dr. Gies' reply, Captain Thompson moved, seconded by Dr. F. E. Clarkson, that a hearty vote of thanks be tendered to Dr. Gies for his presence and for the very interesting lecture which he had given, which, on a vote having been taken, was carried with applause.

Publications Sent Out by the Canadian Oral Prophylactic Association

Care of the Teeth. Dr. Grieve. 1909.

Teeth and Their Relation to Health. Dr. Dowd. 1912.

The C.O.P.A.: Its History and Development (The Executive). 1912.

Teeth and Health. C. N. Johnson. 1912.

Biennial Report of the Educational Committee of the Canadian Dental Association. 1913-14.

Public School Dental Educational Charts. Board of Education, Toronto. 1914.

Biennial Report of the Educational Committee of the Canadian Dental Association. 1915-16.

Charter and By-laws of the Canadian Oral Prophylactic Association. 1916.

The Announcement of the Offer of One Thousand Dollars to Encourage Original Research Work in Canada. 1915.

Skeleton Lectures and Lantern Slides for Public Addresses on
(1) Tooth Decay, Cause and Prevention;
(2) Irregularities of the Teeth;
(3) The Teeth: Their Use and Abuse;
(4) Outline of Lecture on Children's Teeth;
(5) Mastication. Educational Committee. 1915.

The Pathology of Dental Infections and Their Relation to General Diseases. Weston A. Price. 1916.

Military Dental Educational Charts for Military Camps and Hospitals. Educational Committee. 1917.

Military Leaflets on the Care of the Teeth, for Distribution Among Soldiers. Educational Committee. 1917.

New Set of Public School Dental Educational Charts. Educational Committee. 1917.

Annual Report, including President's Address and Financial Statement for the Years 1907 to 1916.

Mouth Infection as it Affects the General Dental Practitioner. M. H. Garvin. 1917.

Mouth Bacteria. W. J. Gies, New York. 1918.